NASA TT F-8123

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DRAFT TRANSLATION

DEC 27 1961 DEC 26 1961

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POLARIZATION OF THE OUTER CORONA ACCORDING TO AIRCRAFT OBSERVATIONS OF THE SOLAR ECLIPSE OF 15 FEBRUARY 1961

X63-10582 Code 2d

(O polyarizatsii vneshney korony po nablyudeniyam s samoleta solnechnogo zatmeniya 15. II. 1961 g.)

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Geomagnètizm i Aeronomiya
Tom I, No. 5, pp.650-652,
Izd-vo A. N. SSSR, Moskva, 1961

FACILITY FORM 602
N71-71162 (ACCESSION NUMBER)
(THRU)
C (PAGES)
(CODE)
(NASA CR OR TMX OR AD NUMBER)
(CATEGORY)

ABSTRACT

According to photographs taken from an aircraft during the total solar eclipse of 15 February 1961, polarization was found along corona's polar and equatorial cross sections at distances of 2 to 5 solar radii from the center of the disk.

COVER-TO-COVER TRANSLATION

The problem of measurement of solar corona's polarization at a distance exceeding 3 solar radii is particularly difficult*). According to reference [1], the brightness of the sky at a distance of 4 solar radii during eclipse equals the corona brightness ($18 \cdot 10^{-10} B_\odot$, where $B_\odot$ is the brightness of the Sun). In order to diminish the brightness of the sky it is necessary to conduct observations from greater heights. However, one of the problems of IZMIRAN division of airborne investigations of the Sun during the solar eclipse of 15 February 1961, was the study of solar corona polarization in a continuous spectrum. In the current work, polarization was investigated at distances of 2.5 to $5R_\odot$ in the 5500 — 6800 Å wave band. Observations were carried out from a TU-104A aircraft at 10 000 meter altitude above Rostov. However, the fact that were conducted through a glass window diminished considerably the advantages of altitude measurement because of light diffusion in the glass. Thus, the polarization values at distances exceeding $5R_\odot$ include very great errors.

*) The distances are counted from the center of the disk.

The exposure time was adjusted for solar corona photographing, and this naturally resulted in an overexposure for the regions at distances of less than 2.5 $R_\odot$.

The height of the Sun during the eclipse was 27° 48', and the instants of the second and third contacts respectively were 11,19 and 11,22 hours. The aircraft was above clouds and the sky was perfectky clear. The total phase was expected to last 163 seconds; however, because the aircraft was catching the shadow of the Moon, it was prolonged to 4 minutes.

A three-lens camera was used for the obtention of corona photographs. A special wide film badge aerophotograhing device constituded its cassette. Indutsar-37 lenses with F = 30 cm and aperture 1/4.5 were utilized. An OC-13 filter stood in front of each of them. The filters' and film's spectral sensitivity curves outlined the region of 5600 - 6800 Å wavelengths. The filter's transmission factor in this region was equal to 90%, sharply diminishing for wavelenghts below 5600 Å. At $\lambda > 7000$ Å the film was losing its sensitivity. A wide 32 cm panchromatic aerophotographic film with a 1000 un.GOSTa sensitivity was utilized. The camera was divided by three blackened partitions in three sections. Three good-quality film polaroids were directly disposed in front of the emulsion. The polaroides' axes were inclined by 120° to one another. The transmission factor at various points of the polaroid is constant with a precision to 2%. A pair of crossed polaroids transmitted in the utilized wavelength 0.8% of the incident light. The camera, mounted on an azimuthal installation, could be guided by hand. The photographs of the corona were made with various exposures. Those of 0.5, 1, 3 seconds were repeated several times. At the same time, because of the insifficient massiveness of the installation and aircraft vibration, the picture of the Sun was shifted by 0.2 $R_\odot$. Phorographs with long exposures (15, 20 s.) were therefore diffuse and unfit for processing.

The revealation was made by a low-contrast revelator Agfa-12 for the obtention of normal blackenings and greatest possible distance range. Together with the photographs of the corona, that of a standard step wedge inprinted with the aid of a GOI sensitometer was also made. The wedge was photographed with 1, 5, 10 and 15 second exposures. A filter with a spectral sensitivity curve similar to analogus filter curves through which the corona was photographed, was utilized. The constant of the wedge is $\lg H_1 - \lg H_2 = 0.18$, where H is the quantity of light incident on the photographic layer. Besides, a six-step clearing agent was inprinted at the edges of every photograph of the corona. The characteristic curves constructed according to this clearing agent and to the step wedge, coincided well.

The photograph measurement was made on a micrphotometer МФ-2 along radial directions through $0.04\ R_\odot$, with $1.57 \times 1.57\ mm^2$ slot dimensions ($0.05 R_\odot$).

The accounting of background intensity introduced a basic error during the exploitation. The background was graphically taken into account, and at the same time its course in the inner corona ($R \leqslant 1.5 R_\odot$) was estimated to be the same as in the lunar disk. At other points it was found by interpolation between that background and the intensity of the photograph's spot that may have been reliably considered free from lighting by the corona. An analogus method was applied by G. M. Nikol'skiy [2]. When using such method of background accounting light diffused by the Sun , and also that diffused in the emulsion, in the camera and the window of the aircraft are excluded. Inasmuch as in our case the spot, free from corona lighting, was taken at a distance of $11 R_\odot$, and the background on the disk of the Moon was substantial, the interpolation was carried out unreliably. Errors in the polarization value $\Delta p/p$ then occurring reached $\pm 40 - 50$ percent. The degree of polarization was determined by the V. G. Fesenkov method

$$p = 2\frac{\sqrt{I_1(I_1 - I_2) + I_2(I_2 - I_3) + I_3(I_3 - I_1)}}{I_1 + I_2 + I_3} = \frac{2I_1 - I_2 - I_3}{(I_1 + I_2 + I_3)\cos 2\alpha}, \qquad (1)$$

where I_1, I_2, I_3 are the corona intensitites respectively for three positions of the polaroid; α — is the position angle of the polarization plane, determined by the relation

$$\operatorname{tg} 2\alpha = \sqrt{3}\,\frac{I_2 - I_3}{2I_1 - I_2 - I_3}. \qquad (2)$$

The processing of two films of the corona, obtained with 0.5 and 1 second exposures was carried out. On the photograph with the 1 s. exposure, the northern, southern, western and eastern sections of the corona were taken, ans also cross sections along the directions at 45° angle to the equator in NW and SE quadrants. On the photograph with 0.5 second exposure, the northern, southern, western and eastern cross sections were processed. The polarization values were averaged for the two photographs, the eastern and western cross sections were unified as equatorial, and the southern and northern — as polar. Reduced together were also the polarization curves disposed at a 45° angle with the equator The mean-square error constituted then 4 percent. The obtained values of the polarization are plotted in Figure 1.

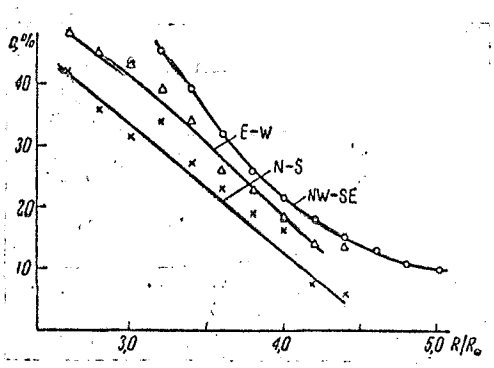

Fig. 1

The polarization values found bu us are greater than those which are obtained according to the Van de Hulst model [1]. Curve 1 of Fig. 2 correspond to the distribution of polarization according to the indicated model for the maximum of solar activity. Curve 2 of Fig. 2 corresponds to the distribution of polarization along the equatorial section according to our data. In was noted in references [4, 5] that for values $R > 3R_\odot$ the Van de Hulst

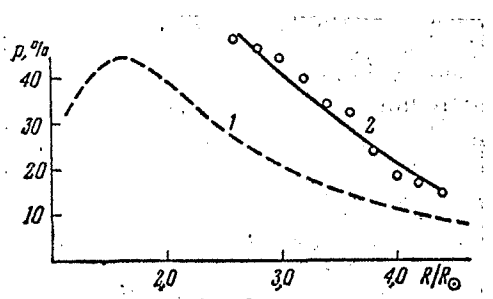

Fig. 2

model gives underrated polarization values. It is interesting to note that in our case the gradient of the curve of polarization distribution is close to that corresponding to the Van de Hulst curve for the maximum of solar activity. A better coincidence is observed for the equatorial cross section curve, and it is worse — for the polar. For the same distances the degree of polarization is lower in polar than in equatorial regions. This attests about the distinction of the 1961 form of the corona from the "maximum". However, the systematically greater value of the degree of polarization for all 1961 corona cross sections probably speak about its greater brightness in comparison with the usual corona of the corresponding phase of activity.

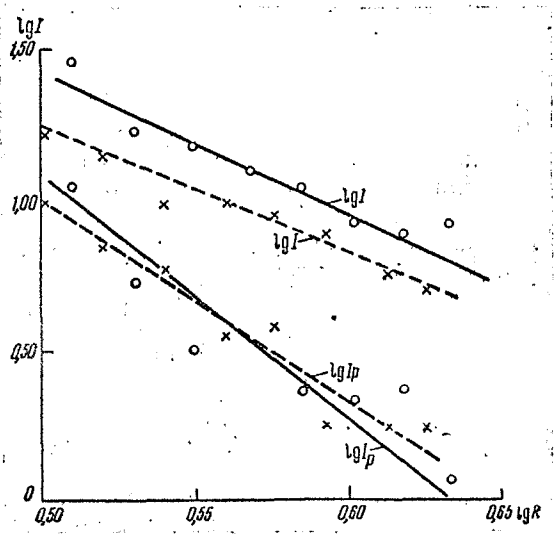

Fig. 3

Fig. 3 shows curves of intensity variation of logarithms (in relative units) of polarized and total corona light relatively to the logarithm of the distance to the center. Solid-line curves and black circles are related to the eastern equatorial cross section of the photograph with the longer exposure. Dotted-line curves and crosses are related to the western equatorial cross section of the photograph with the least exposure. As may have been expected, the total intensity does not drop as steeply as the intensity of the polarized light I_p, which is conditioned by the corona luminescence K. If we express the brightness drop in the corona by the formula $I = I_0 R^{-n}$, we shall have, excusive of polar regions, and at $R = 3 \rightarrow 5$ $R n_{cp}$, 4.2 for the total corona radiation, and 7.1 for the polarized component. The error in the background determination introduces a ~ 30 percent error into the value of I_p

I consider it may duty to convey my thanks to G. M. Nikol'skiy under whose guidance the present work could have been completed.

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Entered on 1 April 1961.

Translated by ANDRE L. BRICHANT
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Washington D.C., 23 December 1961.